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AUTHOR Niaz, Mansoor
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ABSTRACT

The main objective of this paper is to emphasize the importance of integrating qualitative and quantitative research methodologies in science education. It is argued that the Kuhnian incommensurability thesis, a major source of inspiration for qualitative researchers, represents an obstacle for this integration. A major thesis of this paper is that qualitative researchers have interpreted the increased popularity of their paradigm as a revolutionary breakthrough in the Kuhnian sense. Literature from relevant areas is reviewed to show that researchers are far from advocating qualitative research as the only methodology. It is concluded that competition between divergent approaches to research in science education would provide a better forum for a productive sharing of research experiences. Contains 70 references. (Author/JRH)

CAN WE INTEGRATE QUALITATIVE AND QUANTITATIVE RESEARCH IN SCIENCE EDUCATION? --- LEST THE CREVICE MAY BECOME A CANYON

Mansoor Niaz

Chemistry Department, Universidad de Oriente

Apartado Postal 90, Cumaná, Estado Sucre, Venezuela

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ABSTRACT

The main objective of this chapter is to emphasize the importance of integrating qualitative and quantitative research methodologies in science education. It is argued that the Kuhnian incommensurability thesis, a major source of inspiration for qualitative researchers, represents an obstacle for this integration. A major thesis of this chapter is that qualitative researchers have interpreted the increased popularity of their paradigm (research program) as a revolutionary breakthrough in the Kuhnian sense. A review of the literature in areas relevant to science education shows that researchers are far from advocating qualitative research as the only methodology. It is concluded that competition between divergent approaches to research in science education (cf. Lakatos, 1970) would provide a better forum for a productive sharing of research experiences.

INTRODUCTION

A review of the literature shows an increasing interest among science educators with respect to qualitative (phenomenological, ethnographic, interpretive, constructivist, case study) research (cf. Cobern, 1991; Gallagher, 1991; Roth & Roychoudhury, 1992, 1993; Shymansky & Kyle, 1992; Spector, 1984; Tobin & Fraser, 1990; Tobin, Kahle, & Fraser, 1990).

Qualitative research in science education has highlighted the construction of knowledge by the students and its close relationship to their world views. This aspect of research had previously been neglected in science education. Nevertheless, in spite of some important contributions by qualitative researchers it seems that they have neglected important philosophical and epistemological issues that constitute an essential part of the qualitative research program. The main objective of this chapter is a critical appraisal of some of the fundamental underpinnings of qualitative research, that could facilitate integration of qualitative and quantitative research programs. The importance of such an integration is considered to be mutually beneficial and Yeany (1992) has drawn our attention to the dangers of a widening gulf, in eloquent terms: 'After a time, they [Qual and Quan] drew back from the two edges of the crevice which was by now a great canyon isolating the two halves of the community' (p. 1). Similarly, Tobin (1993), in spite of some reservations has endorsed the use of qualitative / quantitative methods depending on the problem to be investigated: 'The theoretical underpinnings of quantitative data were often at odds with those of qualitative data. However, this did not have to be the case. Over time I learned to build a coherence between data types used in my research such that qualitative and quantitative data could contribute in complementary ways to the solutions of problems' (p. 1).

Qualitative researchers, among other sources, have drawn inspiration from Driver & Easley (1978), Freire (1985), Giroux

(1988), Guba & Lincoln (1989), Knorr-Cetina (1981), Kuhn (1970), Lave (1988), Lincoln (1989), and von Glasersfeld (1989). Qualitative research has also been the subject of critical scrutiny. For example, Matthews (1993, 1994) has presented a general critique of constructivism, Suchting (1992) has critiqued Ernst von Glasersfeld and Niaz (1994) has critically appraised Rosalind Driver's major thesis regarding 'the scientific method'. At this stage it is important to note that the debate over the qualitative/quantitative research methodologies has been the subject of much controversy (cf. Gage, 1989; Howe, 1985, 1988; Lincoln, 1990; Maxwell, 1990, 1992; Phillips, 1992; Saloman, 1991; Smith, 1983). The next section presents a critical appraisal of Lincoln's (1989) thesis.

A CRITICAL APPRAISAL OF LINCOLN'S THESIS

One of Lincoln's (1989) main thesis is that of a paradigm revolution in many disciplines (e.g., natural science, brain theory, philosophy, linguistics, politics, etc.). According to Lincoln (1989): '... by paradigm revolution, I mean to denote the call for abandoning scientific method which is occurring in many academic disciplines' (p. 57). The concept of a paradigm revolution is based on a Kuhnian interpretation, summarized by Lincoln (1989) in the following terms: 'As scientists proceed with their work, anomalies occasionally occur. These anomalies represent phenomena

which cannot be either understood or explained by current and existing theories. For some period of time, the anomalies are simply understood as anomalies, until the sheer number and weight of them begins to stretch a given theory's credibility to the point of collapse .... Sooner or later, however, the anomalies begin to take on the appearance of regularities, and a crisis is precipitated, according to Kuhn. In simplest terms, the crisis revolves about whether the scientific community will reject traditional theory and begin anew to construct theory which accounts for the anomalies, or whether it will remain tied to classical theory. A battle ensues between the classicists and the emergent theoreticians ... ' (pp. 60-61). This is a fairly standard Kuhnian account of scientific progress, which has been severely criticized, among others, by Lakatos (1970, 1971). A reconstruction of the history of science, however, presents a different picture. Bohr in order to present his model of the atom based on the emergent paradigm (quantum theory) not only did not discard the classical electrodynamical theory of Maxwell (as required by Kuhn), but rather '... inconsistently grafted [his model] on to Maxwell's theory' (Lakatos, 1971, p. 113). The emerging and the inconsistent nature of Bohr's research program is captured by Lakatos (1970) in truly picturesque terms: '... for Bohr's atom sat like a baroque tower upon the Gothic base of classical electrodynamics' (p. 142).

Lincoln (1989) cites the Schwartz & Ogilvy (1979) content-analysis-like survey at length and consider the following citation as providing support to the new emergent paradigm of qualitative

research:

> '... the emergent paradigm of the actual world is complex, holographic, heterarchial, indeterminate, mutually causal, morphogenetic and perspectival. The shift in metaphor is from the machine to the human being. We are like the world we see' (Schwartz & Ogilvy, 1979, p. 16).

Many science educators, including quantitative researchers would agree to a certain extent with this interpretation of the emergent paradigm. However, a closer look creates many problems. For example, with respect to the movement from linear to mutual causality, Lincoln (1989) concludes: 'In the Newtonian-Cartesian universe, the best causal model is always that one which is simplest, and therefore linear. It is best expressed in the usual "if-then" statements which undergird the formation of hypotheses in conventional scientific inquiry. But newer conceptualizations from both physics and chemistry suggest that some complex systems may be operating in ways which make causality, as we currently understand it, implausible' (p. 71). Let us consider the dilemma of a doctor whose patient's health may depend on a complex interaction of variables, such as cholesterol level, triglycerides, high density lipoproteins (HDL), low density lipoproteins (LDL), etc., and no one variable alone can help to predict the patient's health. So far both the qualitative and the quantitative researchers would perhaps agree on this issue. Nevertheless, a point of departure is signalled as the emergent paradigm would perhaps recommend to the doctor that: we should stop making

quantitative measurements and ignore causal models based on quantitative measurements of the above mentioned variables.

Based on their reading of Schwartz & Ogilvy (1979), the crux of Lincoln's (1989) thesis can be summarized in the following terms:

> 'In a variety of disciplines and subspecialties of disciplines .... including chemistry, mathematics, physics, brain theory, ecology and biology, evolutionary theory, philosophy, politics and political theory, linguistics, religion, studies of types of consciousness (as in biofeedback and the like), and the arts ---- they have abstracted "seven major characteristics of the "new paradigm" that are virtually opposed to those of the dominant paradigm" (logical positivism)' (p. 68).

The 'seven major characteristics of the new paradigm' represent the very ethos of the qualitative paradigm, and if Lincoln's (1989) interpretation is correct we are witnessing a major paradigm revolution as conceptualized by Kuhn (1970). Lincoln (1989) and other qualitative researchers have imbibed so heavily from Kuhn's incommensurability thesis (revolutions interspersed with periods of 'normal science' and that rational debate about competing paradigms is nearly impossible) that they ignore its criticism by other philosophers of science. According to Lakatos (1970), for example: ' "normal science" is nothing but a research programme that has achieved monopoly. But as a matter of fact, research programmes have achieved complete monopoly only rarely and then only for relatively short periods ... The history of science has

been and should be a history of competing research programmes (or, if you wish, "paradigms"), but it has not been and must not become a succession of periods of normal science ...' (p. 155). In the next section I present: a) a wide variety of views of different researchers that do not necessarily share Lincoln's (1989) enthusiasm for the paradigm shift in favor of the qualitative paradigm; b) empirical evidence obtained from citation analysis, as to the robustness of competing research programs in modern psychology, that refute the Kuhnian incommensurability (displacement) thesis.

KUHN'S INCOMMENSURABILITY THESIS: TROUBLE WITH PARADIGMS

Newell (1992) after reviewing the work done in cognitive science forsees the future in the following terms: 'The strongest reason cognitive science should attempt unified theories now is that it has accumulated a vast and elegant body of regularities, highly robust and often parametric. This is especially the product of cognitive psychology and psycholinguistics, which have developed an amazing experimental engine for discovering, exploring, and confirming new regularities' (p. 426, emphasis added).

Flavell (1992) suggests that developmentalists after over a century of study, have found the following seven cognitive-developmental trends during childhood and adolescence: a) increases in information processing capacity; b) increases in domain-specific

knowledge; c) concrete and formal operations; d) the ability to engage in quantitative thinking; d) the acquisition of 'a sense of the game' of thinking; f) the acquisition of metacognitive knowledge and experiences; and g) improvement of the cognitive competencies the child already possesses. As to the future, Flavell (1992) considers that, '.... newly emerging approaches in related fields will invigorate future research .... Possible candidates here are connectionism and neuropsychology (LLamas & Diamond, 1991; McClelland, 1991), dynamic systems theory (Thelen & Ulrich, 1991), comparative developmental psychology (Parker, 1990; Povinelli & deBlois, 1991; Whiten, 1991), evolutionary psychology (Cosmides, 1989), and perhaps "gains-losses" and other conceptualizations of adult cognitive changes (Baltes, 1987)' (p. 1003).

Wittrock & Farley (1989) in their blueprint for the future of educational psychology have endorsed a 'core curriculum' with the following subjects: 'Cognition and instruction, Motivation and emotion, Human development, Individual differences, Social psychology, Technology, learning, and instruction, History and systems of psychology, Measurement, Research methods (quantitative and qualitative) and statistical analysis of data (including the powerful new multivariate techniques), Research practicum' (p. 197, emphasis added). Educational psychology has maintained a close relationship with science education, and thus the reference not only to quantitative and qualitative methods of research, but also to statistical analysis of data is extremely relevant. Qualitative researchers consider the avoidance of statistical analysis as one

of the important underpinnings of their paradigm. Shymansky and Kyle (1992) have made this point very explicitly: 'The dominant research methodology was the agrarian statistical model; little distinction was made between investigating the effects of the amount of fertilizer per acre to maximize yields and profits versus whether the kinds of questions that teachers ask influence students' understanding of science' (p. 755). A episode from the history of science illustrates how cross-domain analogies have played an important role. James Clerk Maxwell's kinetic theory of gases has been the subject of considerable interest for the historians of science. Garber, Brush, and Everitt (1986) have emphasized that the work of greatest influence on Maxwell's development of the kinetic theory of gases may well have been the Essays by Adolphe Quetelet on the Theory of Probabilities in the early 19th century. What, however, is of interest for science educators is that Quetelet was a social scientist and his work dealt with the application of the theory of probabilities to the moral and political sciences. Porter (1981) has argued that since the inspiration for Maxwell's introduction of statistical methods into physics came from a review of Quetelet's work, one should associate Maxwell's early thinking about molecular velocity distributions with the kind of statistical reasoning used in the social sciences by Quetelet and others. This episode from the history of science corresponds quite closely to what Thagard (1992) has referred to as, '... cross-domain analogies, as when Darwin used Malthus's notions of population increase in humans to help

develop his theory of natural selection' (p. 538). Similarly, Niaz (1991) has drawn an analogy (abduction) between Piaget's epistemic subject and the ideal gas law that derives its meaning from the theoretical formulation of the kinetic theory of Maxwell and Boltzmann. If cross-domain analogies are possible in domains so different such as molecular velocities and moral-political issues, then science educators should be more careful in rejecting the use of statistics on the grounds that its theory was first developed for agricultural research.

Carroll (1993) in his address to the Centennial Celebration Symposium, Dynamics in Educational Psychology --- The 20th and 21st Centuries, observed: '... what I believe is the major problem for educational psychology to solve in the 21st century --- namely, how schools can satisfactorily deal with individual differences in learning rates. Perhaps by the end of the 21st century educational psychologists, along with scientists from other disciplines, will have found solutions to this problem.... some of them will come from high technology in computer-assisted instruction and behavior modification or from developments in neuropsychology and changes in DNA' (p. 94).

According to Mayer (1992): 'The main components in a cognitive model of the learning/instruction process ... include the following: instructional manipulations: the external events concerning what is taught and how it is taught; learner characteristics: the internal existing knowledge and information-processing system; learning processes: the internal cognitive

processes engaged during learning; learning outcomes: the internal cognitive structures constructed during learning; and outcome performance: the external performance of the learner on tests' (p. 408).

Kuhnian philosophy has been a major source of inspiration for qualitative researchers and its seems that the following aspects of his philosophy have played an important role: a) It presupposes subjectivity as an integral part of the scientific process, once thought to be wholly objective; b) It asserts that differing paradigms are incommensurate because their core beliefs are resistant to change; c) Paradigms do not merge over time, rather they displace each other after periods of chaotic upheaval or scientific revolution. Kuhnian displacements are not subtle events. They are described as cataclysmic clashes in which losers languish and victors flourish. Despite Kuhn's (1970) detailed explication of scientific revolutions accompanied by historical examples, his incommensurability (displacement) thesis has been a source of considerable controversy (Barker & Gholson, 1984; Lakatos, 1970; Malone, 1993; Reese & Overton, 1972; Segal & Lachman, 1972). Another source of controversy has been with respect to determining when revolutionary displacement is occurring (Friman et al., 1993). Kuhn (1970) himself referred to the subject in the following terms: '... if I am right that each scientific revolution alters the historical perspective of the community that experiences it, then that change of perspective should affect the structure of postrevolutionary textbooks and research publications. One such

effect --- a shift in the distribution of the technical literature cited in the footnotes to research reports --- ought to be studied as a possible index to the occurrence of revolutions' (p. ix). Following Kuhn's (1970) advice, and given the controversy regarding the demise of behavioral psychology and psychoanalysis at the hands of the cognitive revolution (Baars, 1986; Gardner, 1985; Sperry, 1993; Wyatt et al., 1986; Zuriff, 1979), a citation analysis has been conducted by Friman, Allen, Kerwin, and Larzelere (1993). Citation analysis, a bibliometric method that uses reference citations in scientific articles as its principal data, has become an important tool for evaluating various aspects of scientific disciplines (Garfield, Malin, & Small, 1978). According to Friman et al (1993): '... citation analysis could shed light on some of the questions at issue in the debate over a Kuhnian revolution in psychology' (p. 658), and consequently their study addressed the following questions: a) Have citations to articles in cognitive journals increased? and b) Have citations to behavioral and psychoanalytic journals decreased? The study is based on a citation analysis of leading journals in cognitive psychology, behavioral psychology, and psychoanalysis in the 10-year period (1979-1988) analyzed by the Social Science Journal Citation Record (SSJCR), published annually by the Institute for Scientific Information (Garfield, 1979-1988). SSJCR ranks journals according to several citation-related measures, from which the authors (Friman, et al., 1993) selected the following: Source items, Immediacy index, Citation number, and Impact factor. Space limitations do not permit

a detailed analyses of the results. Some of the important findings are summarized below: a) Results show an increase in citations to core journals in cognitive psychology. However, there is no corresponding decreases in citations to core journals in behavioral psychology; b) Citations to core psychoanalytic journals have been decreasing since 1984. This requires an explanation. Authors of psychoanalytic articles frequently cite older classic source items. For example, in 1988, Sigmund Freud was cited almost five times as often as B.F. Skinner and four times as often as Herbert Simon. Interestingly, Freud is still cited more than all other sources in history except Lenin, Shakespeare, Aristotle, the Bible, and Plato. Friman et al (1993) summarize their results in the following terms: '... these findings reflect (and support) the enthusiasm for cognitive psychology that underlies one side of the debate over scientific revolution in psychology' (p. 661). Then the authors ask, 'But do they reflect the displacement that defines scientific revolution?' (p. 661) and respond that the results are not indicative of displacement in the case of behavioral psychology. On the other hand, in the case of psychoanalysis the displacement thesis is weak at best.

INTEGRATION OF QUALITATIVE AND QUANTITATIVE RESEARCH: A VIABLE ALTERNATIVE?

According to Gholson and Barker (1985) Kuhn's incommensurability (displacement) thesis is interpreted by many

researchers to signify that any one science can accommodate only one paradigm. This contentious context of Kuhn's philosophy, '... may be the reason so many prominent scientists have interpreted the increased popularity of cognitive psychology as necessarily signaling the demise of behavioral psychology and psychoanalysis' (Friman, et al., 1993). A major thesis of this chapter is that qualitative researchers have also interpreted the increased popularity of their paradigm as necessarily an indicator of the decline (if not demise) of the quantitative paradigm. Lincoln's (1989) enthusiasm for the qualitative (emergent) paradigm can be observed from the following: '... the philosophical base for the new pattern of research is upon us, in place, and reflects the political, ethical, and social realities found in the world of educational, social, and behavioral research' (p. 73). Similarly, Schwartz and Ogilvy (1979) demonstrate their optimism even more eloquently: 'a shift in paradigm, the evolution of new conceptual maps, a change in world view .... akin in kind, diversity, and magnitude to the emergence of the Enlightenment in the seventeenth and eighteenth centuries' (p. 16). So if these appreciations are correct, we are on the threshold of a new conceptual revolution. Whether a citation analysis would corroborate the paradigm shift or not, is for the future to tell. Nevertheless, the evidence presented in the previous section (Carroll, 1993; Flavell, 1992; Friman et al., 1993; Mayer, 1992; Newell, 1992; Wittrock & Farley, 1989), all dealing with fields that are extremely relevant for science education, does not augur well for the enthusiasm displayed

by the standard bearers of the new revolution. Let us pause for a while and consider the root cause of the display of this enthusiasm. The Kuhnian perspective (incommensurability thesis) on scientific revolution stands out as the major candidate. Friman et al., 1993 consider that, 'Perhaps a more ecumenical philosophy of science would generate fewer fatalistic interpretations of change ...' (p. 664) and suggest the philosophies of Lakatos and Laudan as alternatives, as both, '... emphasized competition between divergent approaches to science. They differed from common interpretations of Kuhn by allowing for productive coexistence of, and exchange between rival approaches ...' (p. 664). On a somewhat different plane, Newell (1992) offers the following advice: 'Theories are alway approximate, often deliberately so, in order to deliver useful answers. Theories cumulate, being refined and reformulated, corrected and expanded. This view is Lakatosian, rather than Popperian: A science has investments in its theories and it is better to correct one than to discard it' (p. 425). Niaz (1993a, 1993b, 1995) has interpreted research in science education from a Lakatosian perspective, primarily as competing research programs. Finally, we run the risk of not only that the crevice may become a canyon (Yeany, 1992) but that we might kill science itself. Winchester (1993) has expressed the crux of the issue in the following terms: 'Why should we expect them [students] to believe, if we teach them that there is, in the end, no truth in science but that there is truth in the history of science or the philosophy of science (which surely rest on shakier ground than,

say, the bulk of physics or chemistry or mathematics)?' (p. 196). Some one more familiar to science educators has cautioned: 'To question the objectivity of observation or the truth of scientific knowledge, one does not need to travel to the wispy world of postmodernism' (Good, 1993, p. 427).

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